QUALITY CHARACTERISTICS AND METRICS RELATED TO M-LEARNING PROCESS

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Abstract

The educational process is a complex service which involves a producer and a consumer. Its complexity increases when mobile platforms are used due their diversity and particularities. In order to have a high quality educational process when using mobile technologies, a continuous quality management process needs to take place at several levels. The levels where the quality management process has to be implemented are: the mobile learning application developer, the mobile learning content provider and the organization that uses mobile learning services (customer). This paper presents a number of factors that influence the quality of digital content and applications software running on mobile devices. Quality management is based on the quality characteristics that need to be identified and quantified. Quality metrics and indicators for mobile learning process were developed. The metrics and indicators have to be integrated in a system in order to assure a high quality management system for mobile learning process. Quality related costs are higher due to mobile learning system complexity.

Keywords: e-learning, mobile learning, educational services, quality metrics, quality management

JEL Classification: D83, I21

Introduction

While the electronic paper provided support for content delivery through the Internet, reducing additional transport costs and time delays, the mobile devices fill gaps of a traditional learning process, through their particular features. One of the main advantages of mobile learning is that the process can take place anywhere and at any time.

It is necessary to provide a quality management process in order to insure a certain degree of quality for mobile learning services. Quality can be observed in the interaction between a producer and a consumer. Product quality is the sum of all technical, economic and social characteristics a product is endowed with in order to fulfill certain social needs – purposes – at a certain moment in time. Service quality is defined by the utility within the required quality boundaries [11]. The quality management process consists of quality planning, controlling and assurance [10].

It is needed to analyze the impact of mobile learning on education quality because this could positively affect the process by providing basic resources for delivering information

to users. A good quality management process in all areas leads to an increased level of quality in the educational system.

The m-learning services are not intended to be used exclusively in the higher education environment. They are intended for all educational processes, at all levels, having a complementary role. The survey presented in this paper focuses on the mobile phone users, with regard to the mobile data services.

1 Mobile learning quality management components

Mobile learning (m-learning) is the process of delivering educational content to individuals through mobile technologies and devices. The basic components of the process are:

- the mobile learning content (MLC) described by text, graphics and multimedia content (audio, video and animation); this type of elements help the learner to acquire and to understand information more easily based on his sensory memory;
- the multimedia educational software (MES) represents the software component of the process and its role is to provide the connection layer between the device and the content and it also makes possible the delivery of information;
- the mobile learning device (MLD) is the hardware component and is represented by any mobile electronic device that can be configured and has a minimal set of features that can provide support for executing and managing software applications; devices that comply with these requirements are PDAs and smartphones (with/without touch screens).

The mobile learning process has evolved as an auxiliary instrument of the traditional education methods. The premise that has allowed that is defined by the fast development trend in the mobile devices area and by the human need to implement the technology that increases the efficiency of existing learning methods. At present there is an estimated ratio of 90% between the number of worldwide mobile devices and global population and that the growth rate in EU mobile devices market for 2009 is of 119% [4]. In addition, with one billion devices per year production rate for mobile phones in 2009, one can say that in theory each person in the world will have the physical resources to be reached by mobile learning process in some way. In developed countries, these rates are greater and studies revealed that young people integrated more rapidly mobile devices in their daily activities. Based on these facts it is important to be understood that one of the objectives of mobile learning is to use the existing infrastructure and to extend the education process outside the classroom.

This is a process that has a continuous evolution based mostly on the technical development of the mobile devices industry. As the technology offers new facilities, the process will include them and will provide more efficient ways to deliver learning content. From early approaches of the mobile learning field, [3] and [12], the mobile device has been upgraded in seven years from the small mono-color screen with limited multimedia features to a personal organizer with full computer characteristics.

The quality management for mobile learning processes can be seen at least at three levels, figure 1:

- Mobile application developer, [13];
- Mobile learning content provider;
- Mobile learning services consumer's organization.

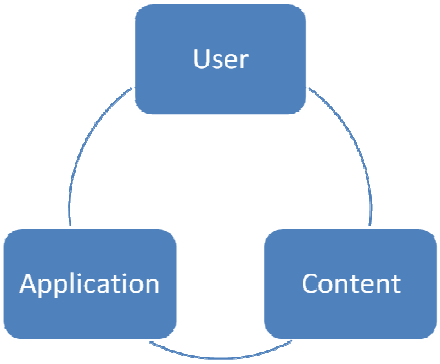

Figure 1 Mobile learning entities

The quality of the application is a term that allows many interpretations, however, despite this flexibility it preserves its role of the most important criteria in analyzing the software product. It is important for both developers and users. The quality of the mobile learning application is described from the viewpoint of software quality characteristics. There are many standards and quality characteristics systems, from which the most known is ISO 9126 [6] and [8], that define several sets of the software characteristics for applications. Taking into consideration this large amount of information and adding to that the cost and time limits of a software development process a straightforward conclusion is the need to focus on several quality characteristics. This set of quality criteria is defined selecting the significant characteristics set for the analyzed software product, the mobile learning application. The risk of ignoring this aspect will render the final results related to quality of application to be less accurate. Furthermore, the objectives of the development process are affected and resources are used in less important areas. Producers target to maximize the general quality levels improving those characteristics which are considered to be critical. The reason for that is the fact that resources are limited and the final quality/cost value must be acceptable. The testing of mobile learning applications has a very important role in increasing the level of quality [14].

The quality process management regarding the educational and informational content is standardized by the ISO/IEC 19796 standard [7].

The organization that implements mobile learning services must define a clear policy regarding user training and educational profile. This provides a high degree of knowledge assimilation for learners.

2. M-learning Applications Quality Characteristics

There are numerous factors that influence the learning process as described in [1]. In the case of mobile learning the situation is more complex because of the process particularities, especially the ones derived from the IT field. This approach takes into consideration that a mobile learning process is an educational one, but also a technical one. It is entirely based on using mobile technologies to deliver educational content and its evaluation means more than the evaluation of a book or another traditional resource. In this scenario, the learning

process quality is influenced by the content quality and by the way it is delivered to students through mobile technologies.

The analysis focused on the technical aspects of mobile learning and mobile learning content (MLC) helps identify several variables that have an important impact on the process: technical features of the mobile device and software characteristics of the application.

An analysis, described in [2] and [5], takes into consideration also the educational features of the software:

- target users from the viewpoint of their age, social background, level of knowledge in the field of the mobile lesson, special abilities or disabilities; there is no universal template for delivering educational content because it must be realized having in mind a particular target group; the analysis of the user is a stage that takes place in the early phase of the MLC development;
- pedagogical characteristics of the multimedia educational software (MES) that allow users to interact, to collaborate between each other or to personalize the virtual environment according to their needs; the mobile lesson must attract learners and must gain their focus because in the m-learning scenario the user is rarely supervised by another person;
- instructional support materials allow developers to use a large set of tools used to deliver content in various formats; the multimedia educational software could implement features like photo or audio galleries, discussion forums, lectures and presentations, assignments and other resources to download on the mobile device;
- type of multimedia support used to deliver content as audio, video, image and text resources;

The technical features of the mobile device refer to:

- physical characteristics of the device as weight, dimensions, type of screen;
- operating system and system operations; these are processes not visible to the users but are influencing the application and represent the base for developing MES;
- user interface that allows users to interact with the application and with other users; it represents the foundation used to get user input into the m-learning application;

The software characteristics describe the quality of the m-learning application. Implementing and reaching a high level of quality for the application is only a stage in the complex process of development. One phase that precedes it is the identification stage of the quality characteristics with the highest impact on the overall quality level. Improving these particular characteristics will lead to the quality level that meets the user expectations.

A survey was made on a group of 400 students in the computer science field [1]. The students will use a mobile learning application in the future. This has helped define a set of quality characteristics that was found by the users to be of higher importance. The analyzed collectivity is homogenous in terms of social characteristics (age between 22 and 23, standard of living), educational characteristics (the students in the last years of studies and at the same specialization, computer science knowledge) and technological point of view (they use regularly mobile devices for data communication as SMS, MMS and Mobile Internet). From a statistical viewpoint, the survey results are representative for a target group formed exclusively by students with a good background in computer technology.

The aim of the survey was not to identify and analyze the relation between the presented quality characteristics. It was aimed to identify their importance from a general point of view. In order to study the interdependencies between these characteristics, the analysis had to concentrate on a real m-learning system which can be tested in a real time environment. The survey has implemented techniques and methods for data analysis specific to software applications, which are described in [9].

The survey has analyzed 15 quality characteristics that were defined by both developers and users. Figure 2 depicts the results of the survey highlighting the first six characteristics, considered most important.

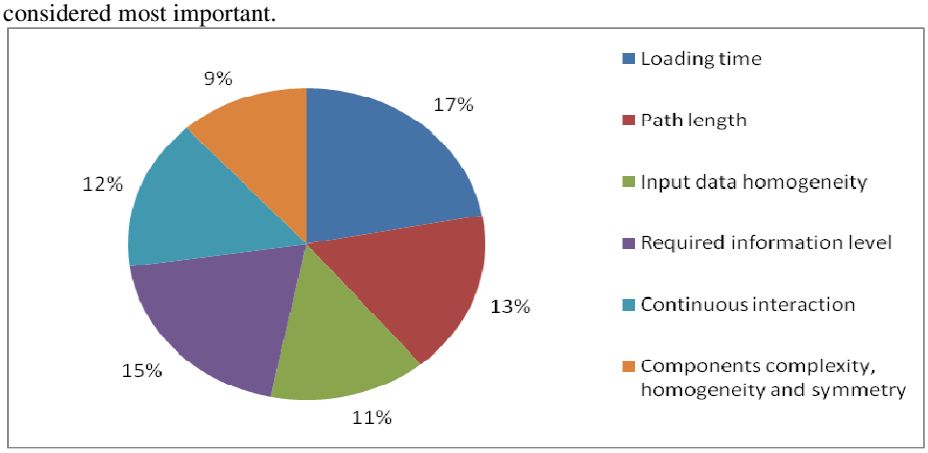

Figure 2 The importance of the first six quality characteristics of mobile learning applications

Quality criteria taken into account for mobile learning applications are [1]:

- *loading time* represents the time the user waits for the page to be downloaded on mobile device and to be interpreted by the browser; for mobile learning applications that do not render multimedia content and that do not contain large components, the loading time should not be greater than a few seconds;
- *path length* to searched resources is equivalent with the graph shortest path or the minimization of tree height; the path dimension is represented as the number of open pages or forms until desired information is reached; it is considered that each mobile learning application has a single start page, or homepage;
- *homogeneity degree of input data process*; the way users interact with the application must be the same for each component; for example, selecting a single option is implemented in the whole application using a combo-box or radio buttons;
- *user required information level*; if there are used forms that require users input data, there must be an appropriate indicator of the required and optional fields, and local data validation must be implemented;
- *continuity of human – application interaction*; there are avoided situations when users reach a dead-end path without having any possibility to select next page to view; despite the fact each Web browser allows users to go back to previous visited page, developers must plan to include controls and links that will offer multiple choices to select next page or to return to a particular one;

- *complexity, homogeneity and symmetry of used components*; the application must preserve a uniform character for all its components; this takes into consideration the way controls are laid out on the interface, how information is presented, the menu of each of application components, the way the results are displayed.

The analysis has highlighted that the first two important characteristics are *loading time* with a 17% importance coefficient and *user required information level* with 15%.

The analysis highlights the costs impact of using mobile learning services. From this point of view, the users are more concerned about the cost of using the m-learning application, cost measured by the time needed to receive and use the content. These two characteristics have an impact also on the financial cost represented by the user mobile monthly subscription, if the m-learning process requires mobile wireless data connections.

3. M-learning Quality Metrics

Each organization involved in the mobile learning process has its own particularities regarding the quality management. Also, there are common processes and activities. The quality management process requires the use of indicators and metrics. These indicators and metrics are developed for each level of mobile learning system. In order to use the indicators and metrics they have to be validated and data to be collected.

The following MLC (mobile learning content) organization indicators and metrics were developed, among others:

- *Content complexity* measures the amount of information in a m-learning lesson and the effort needed for it to be understood by the user; a high value for this metric is generated by delivering large amounts of information concentrated in a limited display;
- *Compression rate* influences the application performance characteristics;
- *Multimedia complexity,* that aggregates the content type: text (T), audio (S), video (V), animation (A) and graphics (G) within the electronic content (EC); this indicator measures the content impact on learning:

$$MC = f(T, S, V, A, G, EC)$$

- *Content source* is important for the overall quality of the learning process; only trusted sources have to be used for a high confidence value;

Quality management for content provider organization has specific characteristics due to subjectivity. Quite often it is hard to quantify and compare the mobile learning content.

The application developer level includes the following indicators and metrics:

- *Lines of code (KLOC)* represents the number of lines of source code express in thousand; this number has to be correlated with the programming language and technologies used;
- *Application complexity* can be calculated in several ways; the well known metrics used are cyclomatic complexity and point functions;
- *User interface learning curve* indicates how fast a user can learn to use the application; it also depends on the user's skills; this has to be quantified;
- *Degree of portability* shows how many systems are supported by the application (expressed in percents); it does not include the partial portability (the application can run on a specific platform but some facilities do not work);

- *The number of features* requires more testing (planning, implementation and running) that leads to higher quality related costs;
- *Multimedia support* is important for mobile learning because of its limited support from mobile platforms; it has to be quantified using relevant multimedia standards;
- *The number of users expected* influences the way how the application is build; when many users are expected, the development of the application needs more effort, especially on the quality assurance part.

There are many results and experience in the area of software quality metrics. The quality management process for m-learning applications relies on this experience but it has to add specific particularities.

At the mobile learning consumer organization level the following indicators and metrics can be used:

- *User level of education* has a great impact on the educational process; it depends on the learning field and also includes the computer skills;
- *Learning curve (speed)* represents needed time to learn using mobile technologies; because of mobility the users can use the mobile learning more than other platforms;
- *User age* influences the learning process especially due to small dimensions of the mobile devices;
- *The degree of satisfaction* measures how the user or organization is satisfied by the educational process and results using mobile learning technologies;

The quality management in consumer's organization varies depending on the organization culture and organization field. These metrics and indicators help to create a common way to compare and to improve the education process in organization.

Quality management is a very expensive process, especially for application testing. In this case, of mobile learning, the quality management related costs are higher than the costs for other type of software. Integration testing costs are also higher than the integration testing costs for the classical applications. For the Web-based and distributed applications there are many possible combinations that have to be integrated and tested (mobile application, content, m-learning server, database server, mobile platform etc.).

Conclusions

The electronic learning process will not replace any time soon the human factor from the learning equation because it requires more than giving and presenting information. There are aspects and specifications that a virtual tutorial cannot reach. For example, the mobile educational software has limited capacities to receive feedback in real time from the student, in order to adjust dynamically the lesson according to his needs and way of understanding.

The mobile learning process must be seen as an instrument of the learning activity. It represents an addition to the wide area of instruments that teachers use to highlight and synthesize important facts for students.

Further research will analyze the characteristics of mobile learning to maximize its impact on delivering information and on helping users to learn.

The complexity of the quality management process for m-learning is arising from the intersection of different domains: education, software development, mobile technologies and content management. Despite its resemblance to a software project, the m-learning process is far more complex and it requires analysis of elements from different fields. This has an additional impact on the overall cost of the quality management process.

The survey has helped identifying important quality characteristics. It has also helped to define quality metrics to be used in the quality management process. These results will stand for the starting point of future research oriented on mobile learning application development, the impact on educational processes and m-learning project management.

This paper presents some results of the research project: *Project management methodologies for the development of mobile applications in the educational system* within the framework of IDEI research program.

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